

# **NASA RELIABILITY PREFERRED PRACTICES FOR DESIGN AND TEST**

## **NASA Technical Memorandum 4322**

### **October, 1995 Supplement (Supplement 5)**

The attached series of Reliability Preferred Practices and Guidelines is the fifth supplement to the initial issue of April 1991 (Reissued September 1991). These practices and guidelines should be inserted in numerical order among the practices provided in the April 1991 edition and updated by the January 1992 and 1993, May 1994, and May 1995 supplements. No changes have been made to those practices; however, the following material has been updated or added for Supplement #5.

- Cover Page
- Center Contacts
- Table of Contents
- Practices as of October, 1995
- Guidelines as of October, 1995
- Section IV. Ground Support Equipment (GSE) Practices
- GSE Practices as of October 1995
- Glossary of Terms and Acronyms
- Keyword Index

This document has grown extensively since its initial issue. Addition of the Index and Glossary by Supplement #3 improved locating specific subject areas and definitions of terms used in the individual practices and guidelines. These two additions replaced the original issue's Appendix A, "Candidate Practices and Guidelines Currently Being Considered for Inclusion in Future Editions..."

A new category of practices for Ground Support Equipment has been added as "Section IV, Ground Support Equipment (GSE) Practices." These practices follow a less complex numbering convention and use only the prefix "GSE" followed by "-3XXX".

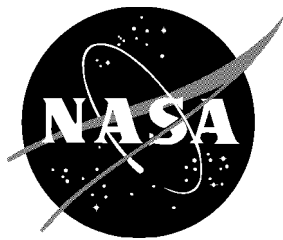
Supplement #4 indicated plans to issue this document through the Government Printing Office as a single, loose-leaf edition containing the initial issue and all supplements. This plan has been changed to providing the document on the World Wide Web. If, subsequent to placing the practices on the Web, we find that a paper or CD-ROM copy of the document is in demand, we will then provide the document in such form(s) of publication. Meanwhile, limited copies of the initial issue and individual supplements may be obtained from the following address or from your local NASA field installation via the Center Contacts listed on page iii.

National Aeronautics and Space Administration  
Code QS  
300 E Street, SW  
Washington, DC 20546

**NASA Technical Memorandum 4322**

# **NASA Reliability Preferred Practices for Design and Test**

NASA Reliability and Maintainability  
Steering Committee  
*NASA Office of Safety and Mission Assurance*  
*Washington, D.C.*



National Aeronautics and  
Space Administration  
Office of Management  
Scientific and Technical  
Information Program

**1991** (Updated with Supplements 1(1992), 2 (1993), 3 (1994), 4 (1995), and  
5(1995))



## PREFACE

This manual summarizes reliability experience from both NASA and industry, and is intended to reflect engineering principles to support current and future civil space programs.

Reliability must be an integral part of the systems engineering process. Although both disciplines must be weighed equally with other technical and programmatic demands, the application of sound reliability principles will be the key to the effectiveness and affordability of America's space program. Experience with our space programs has shown that reliability efforts must focus on the design characteristics that affect frequency of failure. This manual emphasizes that these identified design characteristics must be controlled through the application of conservative engineering principles.

I strongly encourage the use of this manual to assess your current reliability techniques. The manual should promote an active technical interchange between reliability and design engineering that focuses on the design margins, and their potential impact on maintenance and logistics requirements. By applying these practices and guidelines, reliability organizations throughout NASA and the aerospace community, will continue to contribute to a systems development process that assures that:

- Operating environments are well defined and independently verified.
- Design criteria drive a conservative design approach.
- Design weaknesses evident by test or analysis are identified and tracked.

I intend that this manual should be a dynamic medium for technical communication. Additional practices and guidelines will be published periodically. This manual should be considered a series of technical memoranda for promoting a systematic approach to the reliability discipline. Selective use of these practices and guidelines provides the engineering community with the necessary tools to assure the highest possible degree of success in the Nation's civil space program.



George A. Rodney  
Associate Administrator for  
Safety and Mission Quality



## CENTER CONTACTS

In the preparation of this manual, the dedication, time, and technical contributions of the following individuals are appreciated. Without the support of their individual centers, and their enthusiastic personal support and willingness to serve on the NASA Reliability and Maintainability Steering Committee, the practices and guidelines contained in this manual would not be possible.

All of the NASA Centers were invited to contribute to this manual. The people listed below may be contacted for more information about these practices and guidelines.

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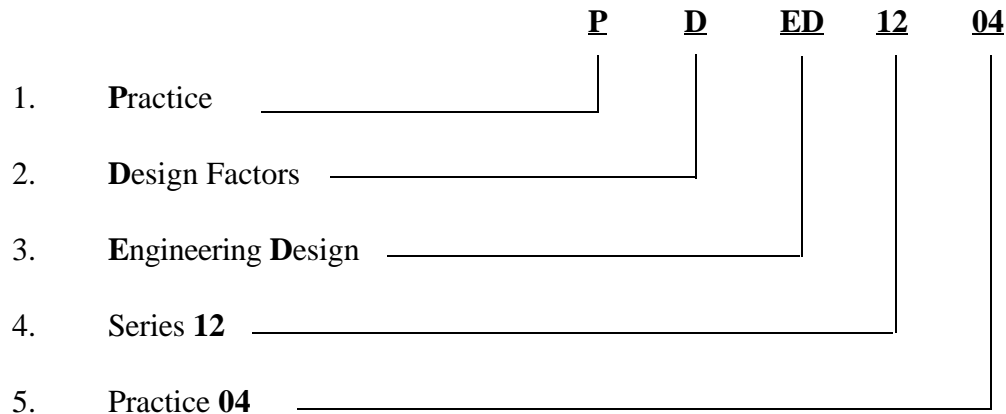
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## DOCUMENT REFERENCING

The following shows the document numbering system applicable to these practices and guidelines. The example illustrated here is “Part Junction temperature,” Practice No. PD-ED-1204.



### Key to Nomenclature

<b><u>Position</u></b>	<b><u>Code</u></b>
1.	G - Guideline P - Practice
2.	D. - Design Factors T - Test Elements
3.	EC - Environmental Considerations ED - Engineering Design AP - Analytical Procedures TE - Test Considerations & Procedures
4.	x - Series Number
5.	xx - Practice Number within Series

A separate category of practices for Ground Support Equipment was added in supplement #5. These practices follow a less complex numbering convention and use only the prefix “GSE” followed by “-3XXX” .

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#### 1100 Series -- Environmental Considerations

- 1101 - Environmental Factors
- 1102 - Meteoroids/Space Debris
- 1103 - Nickel-Cadmium Conventional Spacecraft Battery Handling and Storage Practice
- 1104 - Monitoring DC Magnetic Field Peak Exposure
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#### 1200 Series -- Engineering Design

- 1201 - EEE Parts Derating
- 1202 - High Voltage Power Supply Design and Manufacturing Practices
- 1203 - Class S Parts in High Reliability Applications
- 1204 - Part Junction Temperature
- 1205 - Welding Practices for 2219 Aluminum and Inconel 718
- 1206 - Power Line Filters
- 1207 - Magnetic Design Control for Science Instruments
- 1208 - Static Cryogenic Seals for Launch Vehicle Applications
- 1209 - Ammonia-Charged Aluminum Heat Pipes with Extruded Wicks
- 1210 - Assessment and Control of Electrical Charges
- 1211 - Combination Methods for Deriving Structural Design Loads Considering Vibro-Acoustic, etc., Responses
- 1212 - Design and Analysis of Electronic Circuits for Worst Case Environments and Part Variations
- 1213 - Electrical Shielding of Power, Signal, and Control Cables
- 1214 - Electrical Grounding Practices for Aerospace Hardware
- 1215.1 - Preliminary Design Review

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- 1218 - Application of Ablative Composites to Nozzles for Reusable Solid Rocket Motors
- 1219 - Vehicle Integration/Tolerance Build-up Practices
- 1220 - Demagnetization of Ferromagnetic Parts
- 1221 - Battery Selection Practice for Aerospace Power Systems
- 1222 - Magnetic Field Restraints for Spacecraft Systems and Subsystems
- 1223 - Vacuum Seals Design Criteria
- 1224 - Design Considerations for Fluid Tubing Systems
- 1225 - Conducted and Radiated Emissions Design Requirements
- 1226 - Thermal Design Practices for Electronic Assemblies
- 1227 - Controlling Stress Corrosion Cracking in Aerospace Applications
- 1228 - Independent Verification and Validation of Embedded Software
- 1229 - Selection of Electric Motors for Aerospace Applications
- 1230 - System Design Analysis Applied to Launch Vehicle Configuration
- 1231 - Design Considerations for Lightning Strike Survivability
- 1232 - Spacecraft Orbital Anomaly Report (SOAR) Systems
- 1233 - Contamination Control Program
- 1234 - GPS Timing System
- 1235 - Over-Speed Protection System for DC Motor Driven Cranes
- 1236 - EEE Parts Selection Guidelines for Flight Systems
- 1237 - (Practice Number reserved for future supplement)
- 1238 - Spacecraft Electrical Harness Design Practice
- 1239 - Spacecraft Thermal Control Coatings Design and Application Procedures
- 1240 - Guidelines for the Identification, Control, and Management of Critical Items
- 1241 - Contamination Budgeting of Space Optical Systems
- 1242 - Design Considerations for Space Trusses
- 1243 - Fault Protection
- 1244 - Design Practice to Control Interface from Electrostatic Discharge (ESD)
- 1245 - Magnetic Dipole Allocation

#### **1300 Series -- Analytical Procedures**

- 1301 - Surface Charging and Electrostatic Discharge Analysis
- 1302 - Independent Review of Reliability Analyses
- 1303 - Part Electrical Stress Analysis
- 1304 - Problem/Failure Report Independent Review/Approval
- 1305 - Risk Rating of Problem/Failure Reports

- 1306 - Thermal Analysis of Electronic Assemblies to the Piece Part Level
- 1307 - Failure Modes, Effects, and Criticality Analysis (FMECA)
- 1308 - Electromagnetic Interference Analysis of Circuit Transients
- 1309 - Analysis of Radiated EMI from ESD Events Caused by Space Charging
- 1310 - Spurious Radiated Interference Awareness
- 1311 - Computational Fluid Dynamics (CFD) in Launch Vehicle Applications
- 1312 - The Team Approach to Fault-Tree Analysis
- 1313 - System Reliability Assessment Using Block Diagramming Methods
- 1314 - Sneak Circuit Analysis for Electromechanical Systems
- 1315 - Redundancy Switching Analysis

#### **1400 Series -- Test Elements**

- 1401 - EEE Parts Screening
- 1402 - Thermal Cycling
- 1403 - Thermographic Mapping of PC Boards
- 1404 - Thermal Test Levels
- 1405 - Powered-On Vibration
- 1406 - Sinusoidal Vibration
- 1407 - Assembly Acoustic Tests
- 1408 - Pyrotechnic Shock
- 1409 - Thermal Vacuum Versus Thermal Atmospheric Test of Electronic Assemblies
- 1410 - Selection of Spacecraft Materials and Supporting Vacuum Outgassing Data
- 1411 - Heat Sinks for Parts Operated in Vacuum
- 1412 - Environmental Test Sequencing
- 1413 - Random Vibration Testing
- 1414 - Electrostatic Discharge (ESD) Test Practices
- 1415 - Power System Corona Testing
- 1416 - Radiated Susceptibility System Verification
- 1417 - Electrical Isolation Verification (DC)
- 1418 - Qualification of Non-Standard EEE Parts in Spaceflight Applications
- 1419 - Vibroacoustic Qualification Testing of Payloads, Subsystems, and Components
- 1420 - Sine-Burst Load Test
- 1421 - Eddy Current Testing of Aerospace Materials
- 1422 - Ultrasonic Testing of Aerospace Materials
- 1423 - Radiographic Testing of Aerospace Materials
- 1424 - Leak Testing of Liquid Hydrogen and Liquid Oxygen Propellant Systems

- 1425 - Magnetic Particle Testing of Aerospace Materials
- 1426 - Penetrant Testing of Aerospace Materials
- 1427 - Rocket Engine Technology Test Bed Practice
- 1428 - Practice of Reporting Parts, Materials, and Safety Problems (Alerts)
- 1429 - Integration & Test Practices to Eliminate Damage to Flight Hardware
- 1430 - Short Circuit Testing for Nickel Hydrogen Battery Cells

### **III. RELIABILITY DESIGN GUIDELINES ..... xix**

- A. INTRODUCTION
- B. FORMAT DEFINITIONS
- C. RELIABILITY GUIDELINES

#### **2100 Series -- Environmental Considerations**

#### **2200 Series -- Engineering Design**

- 2201 - Fastener Standardization and Selection Considerations
- 2202 - Design Considerations for Selection of Thick-Film Microelectronic Circuits
- 2203 - Design Checklists for Microcircuits
- 2204 - Concurrent Engineering Guideline for Aerospace Systems
- 2205 - Design and Manufacturing Guideline for Aerospace Composites
- 2206 - Selection of Compatible Materials for Use with Fluorine
- 2207 - Designing for Dormant Reliability
- 2208 - Fabrication of Gaseous and Liquid Fluorine Systems

#### **2300 Series -- Analytical Procedures**

- 2301 - Earth Orbit Environmental Heating
- 2302 - Thermal Analysis of Spacecraft Hardware Guideline
- 2303 - Spectral Fatigue Reliability
- 2304 - Fracture Mechanics Reliability

#### **2400 Series -- Test Elements**

- 2401 - EMC Guideline for Payloads, Subsystems, and Components
- 2402 - Near Field Measurement for Large Aperture Antenna Pattern Determination
- 2403 - Spacecraft Deployed Appendage Test Guidelines

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- **3002 - Fail Safe Fires/Deluge System**
- **3003 - Redundancy in Critical Mechanical Systems**
- **3004 - Use of GSE Design Review Checklists for Launch Vehicles**

#### **APPENDICES**

- Appendix A - Glossary of Terms and Acronymns**
- Appendix B - Index of Key Words**



## **I. OVERVIEW**

### **A. PURPOSE**

This manual is produced to communicate within the aerospace community design practices that have contributed to NASA mission success. The information presented has been collected from various NASA field centers and reviewed by a committee consisting of senior technical representatives from the participating centers.

### **B. APPLICABILITY**

The information presented in this manual represents the “best technical advice” that NASA has to offer on reliability design and test practices. The practices contained in this manual should not be interpreted as requirements, but rather as proven technical approaches that can enhance system reliability. Application of the practices and guidelines is strongly encouraged, but the final decisions regarding applicability resides with the particular program or project office

The manual is divided into two technical sections. Section II contains reliability practices, including design criteria, test procedures, and analytical techniques that have been successfully applied on previous space flight programs. Section III contains reliability guidelines, including techniques currently applied to space flight projects where insufficient information exists to certify that the technique will contribute to mission success.

### **C. DISCUSSION**

Experience with NASA’s successful extended duration space missions shows that four fundamental elements contribute to high reliability: 1) understanding stress factors imposed on flight hardware by its operating environment; 2) controlling the stress factors through selection of conservative design criteria; 3) appropriate analysis to identify and track high stress points in the design (prior to qualification testing or flight use); and 4) careful selection of redundancy alternatives that will provide the necessary function(s) should failure occur.

This manual is provided to encourage design, test, and reliability engineers to give careful attention to both redundancy and stress management during the design and development of space flight systems.

### **D. CONTROL/CONTRIBUTION**

The practices and guidelines contained in this manual serve as a mechanism for communicating the latest techniques that contribute to high reliability. This publication will be revised periodically to include additional practices/guidelines, or revisions to information (as additional technical data becomes available). Contributions from aerospace contractors and NASA Field centers is encouraged. Any practice, guideline or technique that appears appropriate for inclusion

in this manual should be submitted for review. Submissions should be formatted identically to the practices and guidelines in this manual and sent to the address below for consideration::

National Aeronautics and Space Administration  
Code QS  
300 E Street, SW  
Washington, DC 20546

Organizations submitting practices/guidelines that are selected for inclusion in this manual will be recognized in the lower right-hand corner of the published item.

## II. RELIABILITY PRACTICES

### A. INTRODUCTION

This section contains Reliability Design Practices that have contributed to the success of previous space flight programs. The information presented in this section is for use throughout NASA and the aerospace community to assist in the design and development of highly reliable equipment and assemblies. The practices include recommended analysis procedures, redundancy considerations, parts selection, environmental requirements considerations, and test requirements and procedures.

### B. RELIABILITY DESIGN PRACTICE FORMAT DEFINITIONS

The format for the reliability practices is shown below.

#### PRACTICE FORMAT DEFINITIONS

**Practice:** *A brief statement of the practice*

**Benefit:** *A concise statement of the technical improvement realized from implementing the practice*

**Programs That Certified Usage:** *Identifiable programs or projects that have applied the practice*

**Center to Contact for More Information:** *Source of additional information, usually the sponsoring NASA Center. See "CENTER CONTACTS", page iii*

**Implementation Method:** *A brief technical discussion that is not intended to give the full details of the process, but rather to provide a design engineer with adequate information to understand how the practice should be used.*

**Technical Rationale:** *A brief technical justification for the use of the practice*

**Impact of Nonpractice:** *A brief statement of what can be expected if use of the practice is avoided*

**Related Practices:** *Identification of other topic areas in the manual that contain related information*

**References:** *Publications that contain additional information about the practice*

SPONSOR  
OF  
PRACTICE



## PRACTICES AS OF OCTOBER, 1995

<b>PD-EC-1101</b>		<b>Environmental Factors</b>
<b>PD-EC-1102</b>	<b>**</b>	<b>Meteoroids/Space Debris</b>
<b>PD-EC-1103</b>	<b>*****</b>	<b>Nickel-Cadmium Conventional Spacecraft Battery Handling and Storage Practice</b>
<b>PD-EC-1104</b>	<b>*****</b>	<b>Monitoring DC Magnetic Field Peak Exposure</b>
<b>PD-EC-1105</b>	<b>*****</b>	<b>Solar Flare Proton and Heavy Ion Modeling for Single Event Effects</b>
<b>PD-ED-1201</b>		<b>EEE Parts Derating</b>
<b>PD-ED-1202</b>		<b>High Voltage Power Supply Design and Manufacturing Practices</b>
<b>PD-ED-1203</b>		<b>Class S Parts in High Reliability Applications</b>
<b>PD-ED-1204</b>		<b>Part Junction Temperature</b>
<b>PD-ED-1205</b>	<b>*</b>	<b>Welding Practices for 2219 Aluminum and Inconel 718</b>
<b>PD-ED-1206</b>	<b>*</b>	<b>Power Line Filters</b>
<b>PD-ED-1207</b>	<b>*</b>	<b>Magnetic Design Control for Science Instruments</b>
<b>PD-ED-1208</b>	<b>*</b>	<b>Static Cryogenic Seals for Launch Vehicle Applications</b>
<b>PD-ED-1209</b>	<b>**</b>	<b>Ammonia-Charged Aluminum Heat Pipes with Extruded Wicks</b>
<b>PD-ED-1210</b>	<b>*</b>	<b>Assessment and Control of Electrical Charges</b>
<b>PD-ED-1211</b>	<b>*</b>	<b>Combination Methods for Deriving Structural Design Loads Considering Vibro-Acoustic, etc., Responses</b>
<b>PD-ED-1212</b>	<b>*</b>	<b>Design and Analysis of Electronic Circuits for Worst Case Environments and Part Variations</b>
<b>PD-ED-1213</b>	<b>**</b>	<b>Electrical Shielding of Power, Signal, and Control Cables</b>
<b>PD-ED-1214</b>	<b>**</b>	<b>Electrical Grounding Practices for Aerospace Hardware</b>
<b>PD-ED-1215.1</b>	<b>**</b>	<b>Preliminary Design Review</b>
<b>PD-ED-1215.2</b>	<b>***</b>	<b>Hardware Review/Certification Requirement</b>
<b>PD-ED-1216</b>	<b>**</b>	<b>Active Redundancy</b>
<b>PD-ED-1217</b>	<b>**</b>	<b>Structural Laminate Composites for Space Applications</b>
<b>PD-ED-1218</b>	<b>**</b>	<b>Application of Ablative Composites to Nozzles for Reusable Solid Rocket Motors</b>
<b>PD-ED-1219</b>	<b>**</b>	<b>Vehicle Integration/Tolerance Build-up Practices</b>
<b>PD-ED-1220</b>	<b>***</b>	<b>Demagnetization of Ferromagnetic Parts</b>
<b>PD-ED-1221</b>	<b>**</b>	<b>Battery Selection Practice for Aerospace Power Systems</b>
<b>PD-ED-1222</b>	<b>**</b>	<b>Magnetic Field Restraints for Spacecraft Systems and Subsystems</b>
<b>PD-ED-1223</b>	<b>***</b>	<b>Vacuum Seals Design Criteria</b>
<b>PD-ED-1224</b>	<b>***</b>	<b>Design Considerations for Fluid Tubing Systems</b>
<b>PD-ED-1225</b>	<b>***</b>	<b>Conducted and Radiated Emissions Design Requirements</b>
<b>PD-ED-1226</b>	<b>***</b>	<b>Thermal Design Practices for Electronic Assemblies</b>
<b>PD-ED-1227</b>	<b>***</b>	<b>Controlling Stress Corrosion Cracking in Aerospace Applications</b>
<b>PD-ED-1228</b>	<b>***</b>	<b>Independent Verification and Validation of Embedded Software</b>
<b>PD-ED-1229</b>	<b>****</b>	<b>Selection of Electric Motors for Aerospace Applications</b>
<b>PD-ED-1230</b>	<b>****</b>	<b>System Design Analysis Applied to Launch Vehicle Configuration</b>

<b>PD-ED-1231</b>	<b>****</b>	<b>Design Considerations for Lightning Strike Survivability</b>
<b>PD-ED-1232</b>	<b>****</b>	<b>Spacecraft Orbital Anomaly Report (SOAR) Systems</b>
<b>PD-ED-1233</b>	<b>****</b>	<b>Contamination Control Program</b>
<b>PD-ED-1234</b>	<b>****</b>	<b>GPS Timing System</b>
<b>PD-ED-1235</b>	<b>****</b>	<b>Over-Speed Protection System for DC Motor Driven Cranes</b>
<b>PD-ED-1236</b>	<b>****</b>	<b>EEE Parts Selection Guidelines for Flight Systems</b>
<b>PD-ED-1237</b>		<b>(Practice Number reserved for future supplement)</b>
<b>PD-ED-1238</b>	<b>*****</b>	<b>Spacecraft Electrical Harness Design Practice</b>
<b>PD-ED-1239</b>	<b>*****</b>	<b>Spacecraft Thermal Control Coatings Design and Application Procedures</b>
<b>PD-ED-1240</b>	<b>*****</b>	<b>Guidelines for the Identification, Control, and Management of Critical Items</b>
<b>PD-ED-1241</b>	<b>*****</b>	<b>Contamination Budgeting of Space Optical Systems</b>
<b>PD-ED-1242</b>	<b>*****</b>	<b>Design Considerations for Space Trusses</b>
<b>PD-ED-1243</b>	<b>*****</b>	<b>Fault Protection</b>
<b>PD-ED-1244</b>	<b>*****</b>	<b>Design Practice to Control Interface from Electrostatic Discharge (ESD)</b>
<b>PD-ED-1245</b>	<b>*****</b>	<b>Magnetic Dipole Allocation</b>
<b>PD-AP-1301</b>		<b>Surface Charging and Electrostatic Discharge Analysis</b>
<b>PD-AP-1302</b>	<b>*</b>	<b>Independent Review of Reliability Analyses</b>
<b>PD-AP-1303</b>	<b>*</b>	<b>Part Electrical Stress Analysis</b>
<b>PD-AP-1304</b>	<b>*</b>	<b>Problem/Failure Report Independent Review/Approval</b>
<b>PD-AP-1305</b>	<b>*</b>	<b>Risk Rating of Problem/Failure Reports</b>
<b>PD-AP-1306</b>	<b>*</b>	<b>Thermal Analysis of Electronic Assemblies to the Piece Part Level</b>
<b>PD-AP-1307</b>	<b>**</b>	<b>Failure Modes, Effects, and Criticality Analysis (FMECA)</b>
<b>PD-AP-1308</b>	<b>***</b>	<b>Electromagnetic Interference Analysis of Circuit Transients</b>
<b>PD-AP-1309</b>	<b>***</b>	<b>Analysis of Radiated EMI from ESD Events Caused by Space Charging</b>
<b>PD-AP-1310</b>	<b>***</b>	<b>Spurious Radiated Interference Awareness</b>
<b>PD-AP-1311</b>	<b>*****</b>	<b>Computational Fluid Dynamics (CFD) in Launch Vehicle Applications</b>
<b>PD-AP-1312</b>	<b>*****</b>	<b>The Team Approach to Fault-Tree Analysis</b>
<b>PD-AP-1313</b>	<b>*****</b>	<b>System Reliability Assessment Using Block Diagramming Methods</b>
<b>PD-AP-1314</b>	<b>*****</b>	<b>Sneak Circuit Analysis for Electromechanical Systems</b>
<b>PD-AP-1315</b>	<b>*****</b>	<b>Redundancy Switching Analysis</b>
<b>PT-TE-1401</b>		<b>EEE Parts Screening</b>
<b>PT-TE-1402</b>		<b>Thermal Cycling</b>
<b>PT-TE-1403</b>		<b>Thermographic Mapping of PC Boards</b>
<b>PT-TE-1404</b>		<b>Thermal Test Levels</b>
<b>PT-TE-1405</b>		<b>Powered-On Vibration</b>
<b>PT-TE-1406</b>		<b>Sinusoidal Vibration</b>

<b>PT-TE-1407</b>	<b>*</b>	<b>Assembly Acoustic Tests</b>
<b>PT-TE-1408</b>	<b>*</b>	<b>Pyrotechnic Shock</b>
<b>PT-TE-1409</b>	<b>*</b>	<b>Thermal Vacuum Versus Thermal Atmospheric Test of Electronic Assemblies</b>
<b>PT-TE-1410</b>	<b>*</b>	<b>Selection of Spacecraft Materials and Supporting Vacuum Outgassing Data</b>
<b>PT-TE-1411</b>	<b>**</b>	<b>Heat Sinks for Parts Operated in Vacuum</b>
<b>PT-TE-1412</b>	<b>**</b>	<b>Environmental Test Sequencing</b>
<b>PT-TE-1413</b>	<b>**</b>	<b>Random Vibration Testing</b>
<b>PT-TE-1414</b>	<b>**</b>	<b>Electrostatic Discharge (ESD) Test Practices</b>
<b>PT-TE-1415</b>	<b>***</b>	<b>Power System Corona Testing</b>
<b>PT-TE-1416</b>	<b>***</b>	<b>Radiated Susceptibility System Verification</b>
<b>PT-TE-1417</b>	<b>***</b>	<b>Electrical Isolation Verification (DC)</b>
<b>PT-TE-1418</b>	<b>***</b>	<b>Qualification of Non-Standard EEE Parts in Spaceflight Applications</b>
<b>PT-TE-1419</b>	<b>***</b>	<b>Vibroacoustic Qualification Testing of Payloads, Subsystems, and Components</b>
<b>PT-TE-1420</b>	<b>***</b>	<b>Sine-Burst Load Test</b>
<b>PT-TE-1421</b>	<b>****</b>	<b>Eddy Current Testing of Aerospace Materials</b>
<b>PT-TE-1422</b>	<b>****</b>	<b>Ultrasonic Testing of Aerospace Materials</b>
<b>PT-TE-1423</b>	<b>****</b>	<b>Radiographic Testing of Aerospace Materials</b>
<b>PT-TE-1424</b>	<b>****</b>	<b>Leak Testing of Liquid Hydrogen and Liquid Oxygen Propellant Systems</b>
<b>PT-TE-1425</b>	<b>****</b>	<b>Magnetic Particle Testing of Aerospace Materials</b>
<b>PT-TE-1426</b>	<b>****</b>	<b>Penetrant Testing of Aerospace Materials</b>
<b>PT-TE-1427</b>	<b>****</b>	<b>Rocket Engine Technology Test Bed Practice</b>
<b>PT-TE-1428</b>	<b>****</b>	<b>Practice of Reporting Parts, Materials, and Safety Problems (Alerts)</b>
<b>PT-TE-1429</b>	<b>****</b>	<b>Integration &amp; Test Practices to Eliminate Damage to Flight Hardware</b>
<b>PT-TE-1430</b>	<b>*****</b>	<b>Short Circuit Testing for Nickel Hydrogen Battery Cells</b>

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**\*        New Practices as of January, 1992**

**\*\*       New Practices as of January, 1993**

**\*\*\*     New Practices as of May, 1994**

**\*\*\*\*    New Practices as of April, 1995**

**\*\*\*\*\* New Practices as of October 1995**



### III RELIABILITY DESIGN GUIDELINES

#### A. INTRODUCTION

This section contains Reliability Design Guidelines for consideration by the aerospace community. The guidelines presented in this section contain valuable information that in the opinion of the sponsoring activity, represents a technically credible process that could be applied to ongoing NASA programs/projects. Unlike a Reliability Design Practice, a guideline lacks specific operational experience or data to indicate that a topic area has contributed to mission success. However, a guideline does contain information that represents current “best thinking” on a particular topic and is a well thought out approach to resolving a particular issue or problem. There is a unanimous Reliability and Maintainability Steering Committee agreement with the appropriateness of application of the approach.

#### B. RELIABILITY GUIDELINE FORMAT DEFINITIONS

The format for the reliability guidelines is shown below

GUIDELINE FORMAT DEFINITIONS	
<b><u>Guideline:</u></b> <i>A brief statement of the guideline</i>	
<b><u>Benefit:</u></b> <i>A concise statement of the technical improvement realized from implementing the guideline</i>	
<b><u>Center to Contact for More Information:</u></b> <i>Source of additional information, usually the sponsoring NASA Center. See “CENTER CONTACTS”, page iii</i>	
<b><u>Implementation Method:</u></b> <i>A brief technical discussion that is not intended to give the full details of the process, but rather to provide a design engineer with adequate information to understand how the guideline should be used.</i>	
<b><u>Technical Rationale:</u></b> <i>A brief technical justification for the use or the guideline</i>	
<b><u>Impact of Nonpractice:</u></b> <i>A brief statement of what can be expected if use of the guideline is avoided</i>	
<b><u>Related Practices:</u></b> <i>Identification of other topic areas in the manual that contain related information</i>	
<b><u>References:</u></b> <i>Publications that contain additional information about the guideline</i>	
	<div>SPONSOR OF GUIDELINE</div>



## **GUIDELINES AS OF OCTOBER, 1995**

<b>GD-ED-2201</b>	<b>**</b>	<b>Fastener Standardization and Selection Considerations</b>
<b>GD-ED-2202</b>	<b>**</b>	<b>Design Considerations for Selection of Thick-Film Microelectronic Circuits</b>
<b>GD-ED-2203</b>	<b>**</b>	<b>Design Checklists for Microcircuits</b>
<b>GD-ED-2204</b>	<b>***</b>	<b>Concurrent Engineering Guideline for Aerospace Systems</b>
<b>GD-ED-2205</b>	<b>***</b>	<b>Design and Manufacturing Guideline for Aerospace Composites</b>
<b>GD-ED-2206</b>	<b>***</b>	<b>Selection of Compatible Materials for Use with Fluorine</b>
<b>GD-ED-2207</b>	<b>***</b>	<b>Designing for Dormant Reliability</b>
<b>GD-ED-2208</b>	<b>****</b>	<b>Fabrication of Gaseous and Liquid Fluorine Systems</b>
<b>GD-AP-2301</b>		<b>Earth Orbit Environmental Heating</b>
<b>GD-ED-2302</b>	<b>****</b>	<b>Thermal Analysis of Spacecraft Hardware Guideline</b>
<b>GD-ED-2303</b>	<b>****</b>	<b>Spectral Fatigue Reliability</b>
<b>GD-ED-2304</b>	<b>*****</b>	<b>Fracture Mechanics Reliability</b>
<b>GT-TE-2401</b>	<b>**</b>	<b>EMC Guideline for Payloads, Subsystems, and Components</b>
<b>GT-TE-2402</b>	<b>***</b>	<b>Near Field Measurement for Large Aperture Antenna Pattern Determination</b>
<b>GT-TE-2403</b>	<b>*****</b>	<b>Spacecraft Deployed Appendage Test Guidelines</b>

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**\*\*      New Guidelines as of January, 1993**  
**\*\*\*    New Guidelines as of May, 1994**  
**\*\*\*\*   New Guidelines as of April, 1995**  
**\*\*\*\*\* New Guidelines as of October, 1995**



## IV. GROUND SUPPORT EQUIPMENT (GSE) PRACTICES

### A. INTRODUCTION

This section contains design and procedural practices that have contributed to successful ground support of space flight and ground-based aerospace programs. The information presented in this section is for use throughout NASA and the aerospace community to assist in the design, development, and operation of highly reliable ground support equipment and assemblies. This material is primarily concerned with design and test techniques, procedures for control of critical items, and control of environmental influences on successful launch.

### B. RELIABILITY DESIGN PRACTICE FORMAT DEFINITIONS

The format for the reliability practices is shown below.

#### PRACTICE FORMAT DEFINITIONS

**Practice:** *A brief statement of the practice*

**Benefit:** *A concise statement of the technical improvement realized from implementing the practice*

**Programs That Certified Usage:** *Identifiable programs or projects that have applied the practice*

**Center to Contact for More Information:** *Source of additional information, usually the sponsoring NASA Center. See "CENTER CONTACTS", page iii*

**Implementation Method:** *A brief technical discussion that is not intended to give the full details of the process, but rather to provide a design engineer with adequate information to understand how the practice should be used.*

**Technical Rationale:** *A brief technical justification for the use of the practice*

**Impact of Nonpractice:** *A brief statement of what can be expected if use of the practice is avoided*

**Related Practices:** *Identification of other topic areas in the manual that contain related information*

**References:** *Publications that contain additional information about the practice*

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OF  
PRACTICE



## **GROUND SUPPORT EQUIPMENT PRACTICES AS OF OCTOBER, 1995**

<b>GSE - 3001 *****</b>	<b>Flow Fuses for Elimination of Hazards in Pneumatic and Hydraulic Systems</b>
<b>GSE - 3002 *****</b>	<b>Fail Safe Fires/Deluge System</b>
<b>GSE - 3003 *****</b>	<b>Redundancy in Critical Mechanical Systems</b>
<b>GSE - 3004 *****</b>	<b>Use of GSE Design Review Checklists for Launch Vehicles</b>

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**\*\*\*\*\* New Practices as of October, 1995**

